I. OVERVIEW OF THE PEND OREILLE/CLARK FORK SUBBASIN

A. Characterization of the Subbasin

1. Physical and Biological Characteristics

The Clark Fork-Pend Oreille subbasin lies within western Montana, northern Idaho and northwestern Washington. The basin encompasses approximately 25,000 square miles (64,750 km^2) and is the source of waters that enters and leaves Pend Oreille Lake in Idaho. The Clark Fork River begins near Butte, Montana and drains an extensive area of western Montana before entering Idaho and Pend Oreille Lake. The Lake is the source of the Pend Oreille River which enters northwestern Washington from Idaho, which in turn drains into the Columbia River.

Lake Pend Oreille is the largest and deepest natural lake in Idaho. The lake is located in the panhandle region of northern Idaho and lies mostly within Bonner County (Figure 1). A small portion of the southern end extends into Kootenai County. Lake Pend Oreille covered about 83,200 acres (337 km^2) prior to impoundment and now covers 94,720 acres (383 km^2) post impoundment (USFWS 1953; Hoelscher 1993). The lake has more than 175 miles (282 km) of shoreline and has a mean and maximum depth of 538 ft (164 m) and 1,152 ft (351 m), respectively (Rieman and Falter 1976).

Most of the lake's volume (about 95%) is held in the large, southernmost basin, a glacially influenced portion of the Purcell Trench (Savage 1965) with a mean depth of 715 ft (218 m). Average hydraulic residence time in the southern basin is estimated to exceed 10 years (Falter *et al.* 1992). The lake's northern arm is shallower with a mean depth of 98 ft (30 m) and hydraulic residence time of less than one year (Falter *et al.* 1992).

Inflow and outflow of Lake Pend Oreille are regulated by hydroelectric facilities. Cabinet Gorge Dam (completed in 1952) and Noxon Rapids Dam (completed in 1959) by the Washington Water Power Company, are "power peaking" facilities (projects which use river flows to almost instantaneously meet customer demand for electricity, or "load", which fluctuates on an hourly basis) and regulates the Clark Fork River just inside the Idaho - Montana border. Cabinet Gorge operations influence riverine habitats for about seven miles (11 km) in the summer and nine miles (14 km) during the winter (Pratt 1996). WWP maintains a voluntary minimum flow of at least 3,000 cfs below the dam. Limited storage capacity in the WWP Clark Fork projects (Cabinet Gorge and Noxon Rapids) precludes these projects from influencing inflow during high flow events. The Hungry Horse (Bureau of Reclamation) storage project on the South Fork Flathead River, and irrigation practices in Montana, influence flows in the Clark Fork River.

WWP is currently engaged in the Federal Energy Regulatory Commission (FERC) relicensing process for Cabinet Gorge and Noxon Rapids Dams. WWP and relicensing participants are working actively to negotiate and draft a settlement agreement for protection, mitigation, and enhancement measures for the term of the next operating license. Mitigation measures include enhancements for bull trout.

The US Army Corps of Engineers (USACE) operates Albeni Falls Dam on the Pend Oreille River near the Washington border. This facility, constructed in 1952 also, impounds 28 miles (45 km) of the Pend Oreille River and regulates the lake's elevation between 2051 feet above sea level (msl) (winter) and 2062.5 msl (summer). Winter drawdown generally commences after Labor Day. Minimum pool (2051 msl) is normally reached between November 15 and December 1, with a target date of November 15 to facilitate kokanee salmon (*Oncorhynchus nerka*) spawning. The USACE is participating in a three-year study, initiated by IDFG in 1996, to evaluate benefits of leaving the winter lake level higher (2055 msl instead of 2051 msl) to enhance kokanee spawning on the lake shoreline.

Lake Pend Oreille supports a significant sport fishery. In 1991, anglers expended an estimated 465,000 hours fishing the lake with approximately 65% of the effort targeting trout and 35% of the effort targeting kokanee (Ned Horner, IDFG, personal communication). Bull trout comprised a relatively small percentage of the trout harvest, but provided trophy sized fish. The world record bull trout, weighing 32 pounds (14.5 kg) was taken from Lake Pend Oreille in 1949. Legal harvest of bull trout was discontinued beginning in 1996, but bull trout continue to be caught and released by anglers fishing for rainbow trout and lake trout.

Climate

Due to its relative proximity to the Pacific Ocean, climatic conditions in the Pend Oreille Lake watershed are often influenced by maritime weather patterns. Winter storms pass over the area from November through March causing a wet winter season. Summer storms, however, generally pass farther north resulting in relatively dry conditions in the summer. Winds typically prevail from the southwest across Pend Oreille Lake creating exceptionally wet conditions ("lake effect") on the Cabinet Mountains to the northeast.

Average monthly temperatures in the area range from 27°F (-3°C) to 64°F (18°C). Average annual precipitation is 33 inches (84 cm) in Sandpoint, located on the north end of the lake, and exceeds 49 inches (125 cm) in the surrounding mountains (Weisel 1982). In winter, precipitation falls mainly as snow, averaging 88 inches (224 cm) per year. Annual runoff is produced mostly by melting snow in April and May.

The main body of Pend Oreille Lake does not freeze due to considerable latent heat. Shallow areas in the northern portion of the lake do freeze over and form ice cover in some years.

Hydrology

The Clark Fork River flows into the northeast corner of Lake Pend Oreille and is the lake's largest tributary. It drains the Clark Fork River watershed in western Montana, an area of approximately 22,905 sq. mi. (59,324 km^2) (Lee and Lunetta 1990). The river contributes approximately 92% of the annual inflow to the lake (Frenzel 1991a) and most of the annual suspended sediment load. Tributaries to the Clark Fork below Cabinet Gorge Dam include Lightning Creek, Twin Creek, Mosquito Creek, and Johnson Creek. Pack River is the second largest tributary to the lake, and is in turn fed by a number of significant tributary watersheds, including Grouse Creek. Numerous other sub-basins enter Lake Pend Oreille directly, containing both perennial and intermittent streams.

The Pend Oreille River is the only surface outflow from Lake Pend Oreille. The river flows from the lake's northwest corner near Sandpoint for about 27 mi (44 km) before entering Washington. Lake Pend Oreille is hydraulically connected to the Spokane Valley-Rathdrum Prairie Aquifer at the lake's most southern end (Scenic Bay and Idlewilde Bay) and contributes about 11.6 billion gallons (44,000,000 cubic meters) of the aquifer annually (Hammond 1974; Drost and Seitz 1978).

Annual runoff in the Clark Fork River is produced mostly by melting snow, with peak flows typically occurring in May or June, but occasionally in April or July. Tributaries to the lake and lower river in Idaho may experience one or more runoff events. Midwinter rain-on-snow events can result in a rapid snow melt, and in some years the peak flow from tributary watersheds occurs during these events. Due to high precipitation results, location in relation to the lake and prevailing winds, and the tendency for warm winter storms to pick up moisture from the lake, Lightning Creek and other tributaries draining the Cabinet Mountains are particularly susceptible to rain-on-snow events.

Water Quality

Lake Pend Oreille is an oligotrophic (nutrient poor) lake. The lake's trophic status was determined in 1989 (Ryding and Rast) using euphotic zone depth, annual mean total phosphorus concentrations, mean and maximum chlorophyll-*a* concentrations, and mean and minimum Secchi disc water transparency depths. The lake was classified as oligotrophic or ultraoligotrophic ("very nutrient poor") by each parameter except minimum Secchi disc depth (Ryding and Rast 1989).

Woods (1991a) compared recent water quality data to historic data. He reported that the pelagic (open water) zone of Lake Pend Oreille showed no major temporal changes in nutrient concentrations, chlorophyll-*a* concentrations, or secchi disc water transparency depths since the early 1950's.

Nutrient concentrations in shoreline areas and in the northern basin of the lake are considerably higher due to urbanization and suspended sediments in Clark Fork River inflow. Most of the annual phosphorus and suspended sediment load enter the lake via the Clark Fork River (Hoelscher, et al. 1993).

A number of stream segments within the Pend Oreille watershed are listed (1996 303d list) as water quality limited. Caribou Creek, Cocolalla Creek, Fish Creek, Gold Creek Granite Creek, Grouse Creek, North Fork Grouse Creek, Hoodoo Creek Pack River, and Trestle Creek. These streams are listed for various "pollutants of concern" including sediment, habitat alteration, thermal modification and nutrients. Streams listed in the Clark Fork watershed are Johnson Creek, Lightning Creek, East Fork Lightning Creek, Porcupine Creek, Rattle Creek, Spring Creek, Twin Creek, and Wellington Creek. The pollutants of concern in these streams are primarily sediment, flow and habitat alteration (Map 1). The 1998 draft 303(d) list was recently released and may modify this list.

Geology/Landform

The geologic parent materials found in the Pend Oreille watershed are resultant from millions of years of sedimentation, metamorphosis, uplift, and intrusion. Belt series and Kaniksu batholith are the major underlying bedrock types. Underlying geology is an important characteristic which influences fish distribution, abundance, and growth. Streams on the northern and eastern side of Lake Pend Oreille (watersheds in the Cabinet and Bitterroot Mountains) are primarily within the Belt Series bedrock type (sedimentary), and streams draining the Selkirk Mountains are largely within the Kaniksu batholith (granitic bedrock type) (Savage 1965).

The Belt Series are metamorphic sedimentary deposits comprised partially by the Bitterroot and Cabinet mountains. These rocks were formed during the Precambrian period when shallow seas inundated northern Idaho. Sediments of clay, silt and sand settled out of brackish waters as seas retreated, subsequently metamorphosed, and began to fold and fault. The metamorphosed rocks in the basin include argillite, siltite, quartzite, and dolomite (Hoelscher et al. 1993).

The Kaniksu batholith formed about 70 to 80 million years ago when large masses of granite magma rose into the upper part of the earth's crust. As this mass of granite magma rose it caused part of the crust to shear off and move easterly, forming a part of the Cabinet Mountains. The rising magma helped form the Selkirk Mountains.

During the Pleistocene epoch, an ice lobe advanced and greatly over-deepened the lake basin. With retreat of the ice, and consequent flood of glacial melt waters, an outwash plain of poorly consolidated sand, silt, and gravel formed the morainal dam that constitutes the southwest shore of Lake Pend Oreille.

The basin was substantially altered by major glacial events in the late Pleistocene period. The present Clark Fork River valley was alternately plugged and scoured by dams of ice and deposited debris that likely served as the primary feature controlling the level and size of Glacial Lake Missoula. Lake Missoula once covered much of present day western Montana. Existing soils in the watershed are derived from the erosion of Precambrian metasediments and granitic batholith, volcanic deposition, glacial outwash, and alluvium. Most land types have 10 inches (25.4 cm) or more of surface soils composed of Mt. Mazama volcanic ash, which has very high water infiltration rates.

Watersheds in the Cabinet Mountains tend to be more prone to rapid runoff events due to the effects of scour by glacial advances. Glacial advances resulted in highly dissected watersheds (i.e. a high density of streams), shallow soils, and subsoil compaction of glacial tills. The Mt. Mazama ash layer, with its high infiltration rates, is resistant to erosion-causing overland flows. When forest conditions are undisturbed within the Pend Oreille basin, surface erosion is generally low to nonexistent on most upland land types. Mass erosion, however, plays a significant role. Since different layers of till have different water infiltration rates, watersheds draining the Cabinet Mountains tend to have a higher incidence of mass wasting than those in the Pend Oreille basin. As a result of these different till layers, groundwater seeps and springs are more prevalent in tributaries draining the Cabinet Mountains to the north of Lake Pend Oreille. Since glacial outwash makes up most of the valley bottoms in the Cabinet Mountains, and the watersheds are more flashy, in-channel erosion rates are higher than drainages on the eastern side of Pend Oreille. Activities, such as road construction, which intercept groundwater between compacted till layers and the ash layer, can increase surface flow and the potential for mass wasting.

Glaciers acted as ice dams and deposited large amounts of till. Ice in the Pack River Valley dammed most of the tributary streams upstream of their confluence with Pack River, creating a lake, which surrounded much of the valley. Fine sandy sediments deposited in the dammed water are known as glacial fluvial deposits. These sandy areas today appear on mountain side slopes, and are very erosive.

Generally streams on the northern and eastern sides tend to be more productive and have much less fine sediment than streams draining the granitic soils of the Selkirk Mountains. Belt Series streams are more likely to have bedload as a limiting habitat factor, whereas streams flowing from the granitic watersheds of the Selkirk Mountains may have fine sediment limiting habitat condition. Granitic soils tend to be nutrient-poor, and fish growth is typically slower in streams flowing from granitic watersheds. Natural waterfalls are found throughout the basin, and preclude use of several tributaries, or portions of tributaries, by migratory fish.

Topography

The Pend Oreille basin is separated from the Priest River basin to the west by a north-south running ridge (Selkirks) that varies in elevation from 7300 feet (2200 m) in the north to 3600 feet (1100 m) in the south. To the northeast and separating the Pend Oreille-Clark Fork basins from the Kootenai River basin, the southwest facing Cabinet Mountains are less than 6600 feet (2000 m) in elevation. The Purcell Trench is pitched by a gentle divide of less than 2500 feet (750 m) elevation near Elmira where Deep Creek runs north to join the Kootenai River and the southern portion drains into the Pack River.

The ridges to the southeast of the lake which separate the Pend Oreille-Clark Fork basins from the Coeur d'Alene River basin face north and west. They are generally less than 5,000 feet (1500 m) in elevation, although Packsaddle Mountain on the southeast side of the lake reaches an elevation of 6,400 feet (1951 m). The Hoodoo and Cocolalla valleys are separated from the Rathdrum Prairie and the Spokane River basin to the south by a gentle arched plain reaching an elevation of approximately 2,500 feet (760 m). Between Hoodoo Creek and Cocolalla Creek, and between Cocolalla Creek and Pend Oreille Lake are several mountains ranging in elevation from 4,100 feet (1250 m) to 5,000 feet (1500 m). On the west side of Hoodoo Creek is Hoodoo Mountain at 5,000 feet (1500 m) associated with a north-south running ridge separating the basin from Washington drainages. The northern tip of this ridge drains north into the Pend Oreille River.

Spirit Lake and Blanchard Lake drainages are also in the Pend Oreille hydrologic unit however, they are not part of the Pend Oreille/Clark Fork watersheds and will not be addressed in this document. These two watersheds are closely associated with the Rathdrum Aquifer and are separated from each other and from the Spokane River basin to the south by several east-west running ridges.

Vegetation

Historic vegetation patterns were largely influenced by wildfire. Early accounts and photographs of the Pend Oreille basin indicate that old growth stands of western red cedar (*Thuja plicates*) and other species were common in riparian zones and floodplains. Large cedar stumps can still be found in many riparian areas along Pend Oreille basin streams. Watershed uplands were more typically dominated by several species in various stages of succession, with age and composition dependent largely on fire cycles and slope aspect.

Euro-American settlement of the Clark Fork River Valley and Lake Pend Oreille has been accompanied by forest clearing, agricultural development, logging, introduction of nonnative pests, mining, railroad construction, a series of hydroelectric developments, and general urbanization. Forest products are an important commodity from timbered lands which surround the Idaho portion of the watershed. Present vegetation conditions are a product of all of these factors, as well as natural and man-caused fires.

Forest fires have had a profound impact on vegetation within the lower Clark Fork River and Lake Pend Oreille watersheds during the last century. Montana Department of Fish, Wildlife, and Parks (1984) reports that the forest fire of 1910 burned 60% of the Cabinet National Forest, part of what is now the Kootenai and Lolo National Forests. This fire burned an estimated 3,000,000 acres (121 km^2) in western Montana and northern Idaho. The most severely burned areas were reportedly on the north and south slopes of the Bitterroot Mountains (Guth and Cohen 1991; Pratt and Houston 1993) which form the west-southwest flank of the Clark Fork River Valley. One fire ecologist speculated that riparian areas along the Clark Fork River and Lake Pend Oreille might have escaped the fire (Peek 1983 as cited in MDFWP 1984). Other streams in the watershed were burned extensively by timber companies to remove understory vegetation (Humbird lands in Grouse Creek) following riparian and up-slope logging operations (USDA 1993). Following large stand replacing fires, sheep grazing occurred in several watersheds.

Low elevation riparian zones near tributary mouths include areas with and without tree canopy cover. Along stream corridors where tree overstory does not exist or is thin, vegetation includes shrubs and small trees such as thin-leaf alder (*Alnus sinuata*), willows (*Salix spp.*), snowberry (*Symphoricarpos albus*), mountain maple (*Acer glabrum*), red-osier dogwood (*Cornus stolonifera*), blue elderberry (*Sambucus cerulea*), and black hawthorn (*Crataegus douglasii).* Where tree canopy is present, tree species include black cottonwood, (*Populus trichocarpa*) or water birch (*Betula occidentalis*), quaking aspen (*Populus tremuloides*), and a mix of conifer species; including western red cedar, western hemlock (*Tsuga heterophylla*); Douglas-fir (*Psuedotsuga menziesii*), grand fir (*Abies grandis*), and western white pine (*Pinus monticola*). White pine stands have been significantly impacted by white pine blister rust, an introduced pathogen.

Conifer forests in the watershed consist of mixed stands, typified by stands of western red cedar /western hemlock; stands of co-dominant Douglas-fir and Ponderosa pine (*Pinus ponderosa*); and stands of Douglas-fir, western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*) and western white pine. Dense stands of Douglas-fir, larch, and lodgepole are characteristic of slopes with north and east aspects. Relatively open stands of Douglas-fir and Ponderosa pine are typical on the warmer, dryer slopes with south and west aspects.

Representative species of upland shrubs include western serviceberry (*Amelachier alnifolia*), mountain maple, snowberry, mountain balm (*Ceanothus velutinus*), mallow ninebark

(*Physocarpus malvaceus*), huckleberry (*Vaccinium spp*), and others.

Vegetation can strongly influence conditions in streams. Canopy cover adjacent to streams provides shade and helps to maintain cooler water temperatures during summer months. Conifers may also provide insulation during winter months, reducing freezing and formation of anchor ice. Large trees which fall into streams and floodplains help to shape channels, create pools, provide cover and shade, introduce and store nutrients, dissipate stream energy, and contribute to overall channel stability (Murphy and Meehan 1991). Riparian vegetation also plays an important role in providing stream bank stability through binding of soils by roots. The amount, type, and stage of vegetation in a watershed can also influence stream flows. Vegetation removal by fire or timber harvest can result in increased peak flows during storm events and increased summer flows (Harr 1981; King 1989). Increased peak flows during winter months, when bull trout eggs are incubating, may reduce hatching success.

Fisheries

A wide diversity of fish species are present in Pend Oreille Lake an its tributaries. The native sport fish are westslope cutthroat trout, bull trout, and mountain whitefish. Other sport fish that have been stocked or found their way into the lake over the years include kokanee, rainbow trout, Gerrard (Kamloops) rainbow trout, lake whitefish, brook trout, brown trout, lake trout, yellow perch, black crappie, largemouth bass, brown bullhead, pumpkinseed, and northern pike. Other fishes include northern squawfish, large-scale sucker, longnose sucker, peamouth, redside shiner, slimy sculpin, torrent sculpin, longnose dace, pygmy whitefish, and tench.

In 1889, the U.S. Fish Commission introduced 1.3 million lake whitefish fry. Kokanee, which is a landlocked salmon, appeared in the lake about 1933. The original stock likely migrated into the lake via the Flathead and Clark Fork Rivers from Flathead Lake in Montana. During 1937, an unknown cause created a tremendous die-off of lake whitefish. As lake whitefish numbers declined, kokanee became very abundant. In 1941 or 1942, the presence of abundant kokanee prompted the introduction of Gerrard rainbow trout, a top level predator, from Kootanay Lake, British Columbia (Corsi *et al* 1998).

Other salmonids have been introduced into the Pend Oreille drainage including brook trout, brown trout, lake trout, and arctic grayling. The arctic grayling introduction apparently failed as there are no catch records for this species. Lake trout and brown trout have established populations in the lake and provide some harvest. Brook trout occur primarily in the tributaries. It is not known when yellow perch, black crappie, or largemouth bass were introduced into Pend Oreille Lake. These species compose an important part of the fish community in the shallow bays of the northern and western part of the lake. The westslope cutthroat trout fishery has declined more dramatically than any other Pend Oreille Lake fishery. It is now very reduced and is being supported by fingerling stocking (Hoelscher *et al* 1993).

Bull Trout

In the Pend Oreille Lake basin only adfluvial populations of bull trout are known to exist, their movements now limited by Albeni Falls Dam and Cabinet Gorge Dam. Adfluvial bull trout spawn in tributary waters where the juveniles rear from one to four years before migrating to the lake where they grow to maturity. In 1998 the U.S. Fish and Wildlife Service listed the bull trout as a threatened species under the Endangered Species Act. The Pend Oreille watershed is a high priority for efforts related to the recovery of the species. Idaho is preparing a conservation plan to restore bull trout populations in the state. This conservation plan may be incorporated into the implementation phase of applicable TMDLs (Corsi *et al* 1998).

2. Cultural Characteristics

A 1990 study by Lee *et al.* Identified twelve different land cover types in the subbasin. The largest land cover type is forested followed by the 86,018 acres (348 km^2) of water of the Pend Oreille Lake (Table 1).

Table 1. Acreage of land cover types for the Pend Oreille and Clark Fork watersheds (Lee 1990).

Land Cover Type	Pend Oreille (acres)	Clark Fork (acres)	Total (acres)
Forest	276,800	21,313	298,113
Forest (thinned)	100,380	7,692	108,072
Forest (clearcut)	1,130	231	1,361
Rangeland	67,044	4,547	71,591
Agriculture (cropland/pasture)	27,859	3,579	31,438
Barren Land	11,010	28	11,038
Urban	6,655	0	6,655
Wetland	746	323	1,069
Debris (Clark Fork Delta)	0	9	9
Water (Pend Oreille Lake)	86,018	0	86,018
Water (Clark Fork River)	0	1,138	1,138
Water (other lakes, streams, rivers)			3,249
Total	580,891	38,860	619,751

The 1990 Bonner County census estimated a total population of 26,622 (U.S. Bureau of Census 1990). The population increased to an estimated 34,800 people in 1997 and a projected population of 50,500 people by the year 2020. This is double the growth rate of similar areas in Montana (NPA DATA Services 1997).

The Pend Oreille/Clark Fork subbasin contains lands under mixed ownership. Privately owned land comprises 48% of the subbasin, however, in Lee's analysis of seven 303(d) listed watersheds, roughly 81% of the land is owned by the U.S. Forest Service and privately held lands comprise 17% of the total acreage (Figure 1 and Table 2.).

Table 2. Land ownership/management in seven Pend Oreille/Clark Fork watersheds (Lee 1990).

Watershed	Total Acres	% Private	%USFS	% State	%BLM
Trestle Cr.	14,713	13.8	83.0	2.5	0.7
Gold Cr.	15,666	10.3	87.7	0	0
Granite Cr.	18,249	2.1	97.9	0	0
Johnson Cr.	15,659	19.9	79.4	0	0
Twin Cr.	18,209	24.6	75.2	0	0.2
Pack River	101,207	36.0	55.0	6.6	2.4
Lightning Cr.	73,052	11.2	86.3	0.4	0.8

Historically, Bonner County had a resource based economy, producing timber, agricultural products and mined minerals. However, this resource based sector has been replaced by a growing services, retirement, and recreation based economy (ASARCO 1998).

B. Sub-basin Pollutant Source Inventory

The major sources of pollutants in the Pend Oreille and Clark Fork watersheds are: hydropower dams, mining, timber harvest, urban development, industrial discharge, historical fires, loss of riparian habitat, agriculture, livestock and roads.

1. Summary of Past & Present Pollution Control Efforts

There is a long history of citizens and agencies working together to protect or restore water quality in the Clark Fork and Pend Oreille watersheds. Below are a few of the groups who have contributed to the effort:

Tri-State Implementation Council
Lake Pend Oreille Idaho Club
Alliance for the Wild Rockies
Public Lands Council
Trout Unlimited
Cabinet Resource Group
Idaho Rivers United
Cocolalla Homeowners Association
Pend Oreille River Homeowners Association
Sewer Districts
Stream Segments of Concern Local Working Committees
Clark Fork Superfund sites cleanup

These organizations and others have been and continue to be, very effective in the protection of water quality in the Pend Oreille and Clark Fork watersheds.